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Difference in dose to water for photon beams with and without the presence of a magnetic field.

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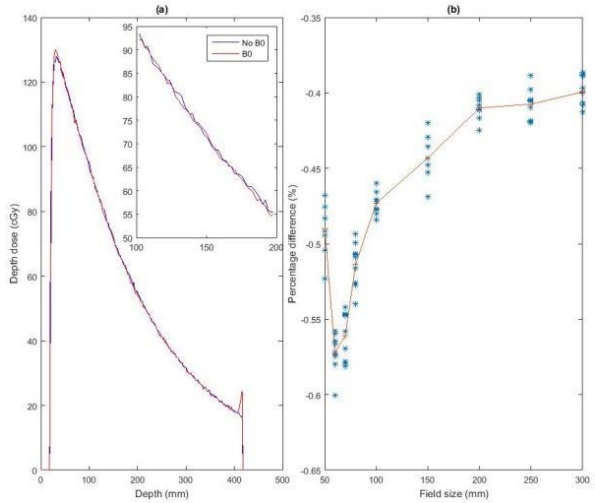
Purpose or Objective: In MRI guided radiotherapy (e.g. MR-linac), radiation is delivered in presence of a magnetic field. Therefore, the dose deposition is different since the path of the secondary electrons is changed due to the Lorentz force. Especially at air-tissue interfaces this causes changes in dose distribution. An example is the change in reading of a ionization chamber in a magnetic field. Besides, since the electrons are bend, the net effect is that electrons will travel less in forward direction, as a result the local dose deposition will change slightly even in an area with homogenous density. How to account for these changes in the various codes of practice for reference dosimetry is yet under debate. The purpose of this abstract is to quantify the change in dose-to-water (for a fixed setup) when applying a magnetic field.

Material and Methods: The Monte Carlo (MC) dose engine from Monaco TPS (Elekta) was used to estimate the change in dose-to-water. Validation of this MC code against other established MC codes has been performed by other research groups. For different square field sizes (from 5 to 30 cm) the dose deposition of a 6MV photon beam of an Elekta Agility linac is calculated in a water phantom of 50x50x40 cm^3 (SAD = 100 cm, SSD = 90 cm). Calculations were performed with and without a transversal 1.5T magnetic field for the same number of MU. MC variance was 0.1%. Difference in dose was calculated by means of the percentage difference in depth dose in a volumetric region below dose maximum and above phantom bottom (5<depth<35 cm) and around the central axis. A histogram of the percentage differences was calculated for all field sizes. Subsequently, a Gaussian function is fitted to the peak region of the histogram (central part) to reduce the binning effects.

Results: In figure (a) an example of a depth dose curve (and close up) with and without magnetic field is shown for field size 10x10 cm^2. Figure (b) shows the percentage difference for all square field sizes (9 sample point per field size). The mean percentage difference for all field sizes ranges between -0.4% and 0.55%.



These results show, within the MC variance, that a tendency is visible over the different field sizes. This may be caused by the change in phantom scatter for different field sizes. However, the MC variation causes large variation in the ratio. For small field sizes (<5x5 cm^2) penumbra effects will come into play and are for that reason disregarded. The effect of beam hardening is neglected in this work.

Conclusion: A difference in dose-to-water can be estimated as -0.45% for a 10x10 cm^2 field, which is related to the fact that the electrons travel less in forward direction. Note that this dose difference can also be expressed as a shift in PDD (in the order of a mm). Depending on the used code of practice for reference dosimetry, this difference needs to be taken into account when applying correction factors for magnetic field effects.

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Evaluating a versatile new-generation anthropomorphic phantom for SBRT and thoracic IMRT/VMAT

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Purpose or Objective: Time-efficient dose delivery by volumetric modulated arc therapy (VMAT) for stereotactic body radiation therapy (SBRT) is gaining more and more interest in radiation oncology. The combination of VMAT with potentially-lethal SBRT doses in heterogeneous tissue circumstances has led to an emerging use of anthropomorphic phantoms for quality assurance (QA) of both therapeutic target dose coverage and organ-at-risk (OAR) sparing. In this study, the first evaluation worldwide of a new-generation anthropomorphic phantom (E2E SBRT phantom model 036A CIRS INC., Norfolk, VA) was conducted for dose delivery of spine and lung SBRT using VMAT.

Material and Methods: The phantom mimics the thorax anatomy with lung-tissue surrounded by rib structures and vertebrae, allowing appropriate image-guidance with a subsequent anthropomorphic dose evaluation. The phantom was customized to fit an Exradin A1SL (Standard Imaging, Middleton, WI) ionization chamber (IC) in the tumor centroid and in the peripheral lung. Also TLD or alanine pellets cutouts are foreseen in the phantom. In thoracic and pelvic part of the phantom, both an axial and coronal plane are available for comparing calculated and measured film dose in the target area. A lung insert with a kidney-shaped tumor was specifically developed to verify VMAT lung SBRT with film and IC. The kidney-shaped lung tumor also allowed for a dose film evaluation of the isodose levels along both the medial concave and lateral convex border of the tumor. External markings on the insert allowed to simulate the influence of a rotational tumor offset (step size 1°) with respect to the planning CT.

Results: To already illustrate the potential of the phantom, initial QA results obtained from the new phantom for a spine SBRT and a lung lesion with VMAT SBRT were visualized in Figure 1A and 1B. Overall, a good agreement was found between dose calculation of the treatment planning system and respectively film (>88%) (absolute dose) and IC (<3%) measurements. The difference in agreement score for an OAR close to respectively the concave or convex border of the tumor was similar (see Figure 1B). With 2 and 5 mm PTV margins for respectively spine and lung SBRT, up to 1° and 3° rotation of the phantom insert led to an adequate target coverage.